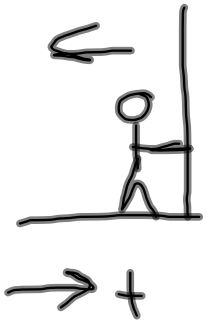
Momentum:

- Conservation $\vec{p}_i = \vec{p}_f$
  - Elastic
  - Inelastic
- Impulse - Momentum Theorem
  - $\vec{J} = \Delta\vec{p}$
- Problem types:
  - Impulse - Momentum
  - 1-D elastic
  - 1-D inelastic
  - 2-D inelastic
  - 1-D spring explosion

A 53 kg skater is standing still in front of a wall. By pushing against the wall she propels herself backward with a velocity of -1.6 m/s. Her hands are in contact with the wall for 0.80 s. Ignore friction and wind resistance, and find the magnitude and direction of the average force she exerts on the wall.



$$\bar{J} = \Delta\bar{p}$$

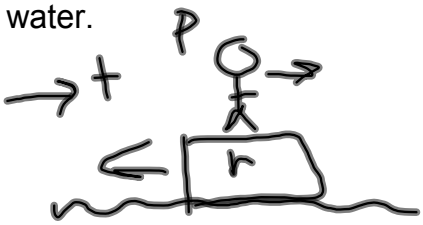
$$\bar{F}\Delta t = m\Delta\bar{v}$$

$$F = \frac{m(v_f - v_i)}{\Delta t}$$

$$= \frac{(53\ kg)(-1.6\ m/s - 0\ m/s)}{.8\ s}$$

$$= -106\ N$$

A 55 kg swimmer is standing on a stationary 215 kg floating raft. The swimmer then runs off the raft horizontally with a velocity of 5.1 m/s relative to the shore. Find the recoil velocity that the raft would have if there were no friction and resistance due to water.



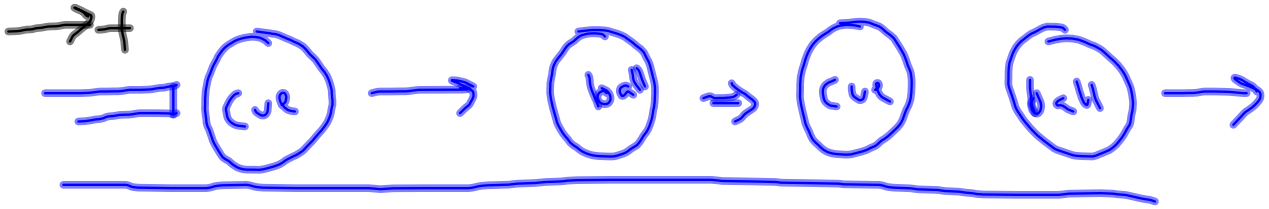
$$(m_p + m_r)\vec{v}_i = 0 = m_p\vec{v}_{pf} + m_r\vec{v}_{rf}$$

$$-m_p v_{pf} = m_r v_{rf}$$

$$v_{rf} = -\frac{m_p v_{pf}}{m_r}$$

$$= -1.30 \text{ m/s}$$

A cue ball (mass = 0.165 kg) is at rest on a frictionless pool table. The ball is hit dead center by a pool stick which applies an impulse of +1.3 N*s to the ball. The ball then slides along the table and makes an elastic head-on collision with a second ball of equal mass that is initially at rest. Find the velocity of the second ball just after it is struck.



$$\bar{P}_{ci} + \bar{P}_{bi} = \bar{P}_{cf} + \bar{P}_{bf}$$

$$\bar{P}_{bi} = 0 \qquad \bar{P}_{cf} = 0$$

$$\bar{P}_{ci} = \bar{P}_{bf}$$

stick on cue ball

$$\bar{J} = \Delta \bar{P}_c$$

$$\bar{J} = \bar{P}_{cf} - \bar{P}_{ci}$$

not the same

$$\bar{P}_{cf} = 1.3\ \text{kg}\cdot\text{m/s}$$

$$\bar{P}_{bf} = \bar{P}_{ci}$$

$$m_b \bar{v}_{bf} = \bar{P}_{ci}$$

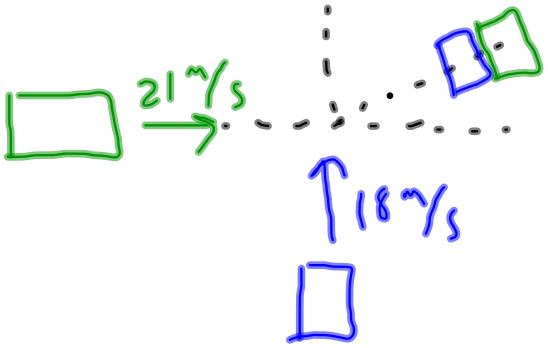
$$v_{bf} = \frac{P_{ci}}{m_b}$$

$$= \frac{1.3\ \text{N}\cdot\text{s}}{.165\ \text{kg}}$$

$$= 7.88\ \text{m/s}$$

Momentum Review and Practice Problems 10.10.11 AP Physics

A green car with a mass of 1100 kg is traveling at 21 m/s to the east and a blue car with a mass of 1500 kg is traveling at 18 m/s to the north. Find the magnitude, angle, and direction of the resultant velocity of the cars stick together when they collide.

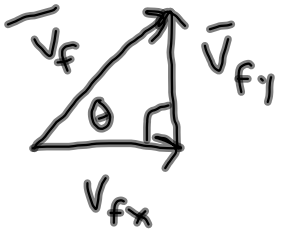


$$m_g \bar{v}_{gix} + \cancel{m_b \bar{v}_{bix}} = (m_g + m_b)\bar{v}_{fx}$$

$$\cancel{m_g \bar{v}_{giy}} + m_b \bar{v}_{biy} = (m_g + m_b)\bar{v}_{fy}$$

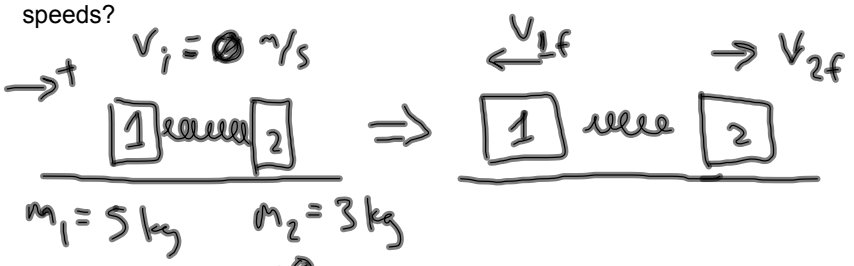
$$v_{fx} = \frac{m_g v_{gix}}{m_g + m_b} = 8.88 \text{ m/s}$$

$$v_{fy} = \frac{m_b v_{biy}}{m_g + m_b} = 10.38 \text{ m/s}$$



$\bar{v}_f = 13.6 \text{ m/s} \ @ \ 49.5° \text{ N of E}$

A massless spring of spring constant 20 N/m is placed between two carts. Cart 1 has a mass of 5 kg and Cart 2 has a mass of 3 kg. The carts are pushed toward one another until the spring is compressed a distance 1.3 m. The carts are then released and the spring pushes them apart. After the carts are free of the spring, what are their speeds?



$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

$$\frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2 + \frac{1}{2} k x_i^2 = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2 + \frac{1}{2} k x_f^2$$

$$-m_1 v_{1f} = m_2 v_{2f} \Rightarrow v_{2f} = \frac{-m_1}{m_2} v_{1f}$$

$$k x_i^2 = m_1 v_{1f}^2 + m_2 v_{2f}^2$$

$$k x_i^2 = m_1 v_{1f}^2 + m_2 \left(-\frac{m_1}{m_2} v_{1f}\right)^2$$

$$k x_i^2 = m_1 v_{1f}^2 + \frac{m_2 m_1^2 v_{1f}^2}{m_2^2}$$

$$v_{1f}^2 = \frac{k x_i^2}{m_1 + \frac{m_1^2}{m_2}}$$

$$v_{1f} = -\sqrt{\frac{k x_i^2}{m_1 + \frac{m_1^2}{m_2}}}$$

$$= -1.59 \text{ m/s}$$

$$-m_1 v_{1f} = m_2 v_{2f}$$

$$v_{2f} = \frac{-m_1 v_{1f}}{m_2}$$

$$= 2.60 \text{ m/s}$$